Draft
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Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Concept of Operations

December 13, 2004

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1 Introduction

1.1 NOAA'S Mission Statement

The goals of the Geostationary Operational Environmental Satellites (GOES) program are to procure spacecraft, instruments, launch services, and a ground segment necessary to maintain an uninterrupted flow of environmental satellite data to users. Improvements to be implemented on the GOES series of satellites are required to support NOAA's mission objectives. These objectives are

- Protect, restore, and manage the use of coastal and ocean resources through ecosystem management approaches;
- Understand climate variability and change to enhance society's ability to plan and respond;
- Serve society's needs for weather and water information;
- Support the Nation's commerce with information for safe and efficient transportation (e.g., commercial aviation, utilities, commercial shipping, etc);
- Provide critical support to NOAA'S mission.

Examples of GOES products together with their uses are:

1) Cloud images and precipitation estimates for hurricanes and other coastal storms;
2) NOAA Coast Watch sea surface temperature for locating commercial and sport fish, and protected marine species;
3) Ocean surface currents, water temperature and sea state for both ecosystem management and marine navigation safety;
4) Surface temperature and precipitation monitoring for use with the Climate Reference Network to specify reference quality data;
5) Images of the United States and adjacent ocean areas to enable the detection of hurricanes and other major weather events;
6) Quantitative environmental data such as temperature, moisture, wind, radiation and solar energy particle flux for use in weather predictions, hydro-metrological flux, climate long term trending, ecosystems management, commercial economic gain, and transportation safety;
7) Environmental data for air, land, and marine transportation;
8) Space environmental data to prevent damage to communications satellites.

GOES-R also provides communications services used to relay data from remote observing platforms such as buoys and rain gauges for use in numerical weather prediction models and flood/drought assessments.

1.2 System Overview

The government is currently preparing for the procurement of the next-generation GOES series to continue to satisfy its mission while meeting new requirements specified in the GOES-R Mission Requirements Document (MRD). This new series, designated as GOES-R, advances the instrument technology of GOES satellites by twenty years; it is the first major improvement in instruments since GOES-I was launched in 1994. (GOES-R is planned for launch in 2012.) The GOES-R series will introduce new technology in both the Space and Launch Service (referred to below as the Space Segment) and the Ground Segment. These technological advances will improve our nation's ability to monitor and forecast weather and environmental phenomena, and will provide a four-fold increase in the types of products produced (from 41 products today to more than 160 products in the GOES-R era). Complexity, availability requirements and cost considerations drive GOES-R operations towards increasing automation compared to operations of earlier GOES systems.

A general overview of the GOES-R System is given in Figure 1-1. GOES-R satellites will have two operational locations; 75°W and 135°W. Any GOES-R spare satellite will be stored at 105°W. The primary instruments are the Advanced Baseline Imager (ABI), which will provide imaging, and the Hyperspectral Environmental Suite (HES), which will provide disk sounding of the earth, mesoscale severe weather sounding, and coastal water imaging. Secondary missions for both satellites will include Global Rebroadcast (GRB) and unique payload services.

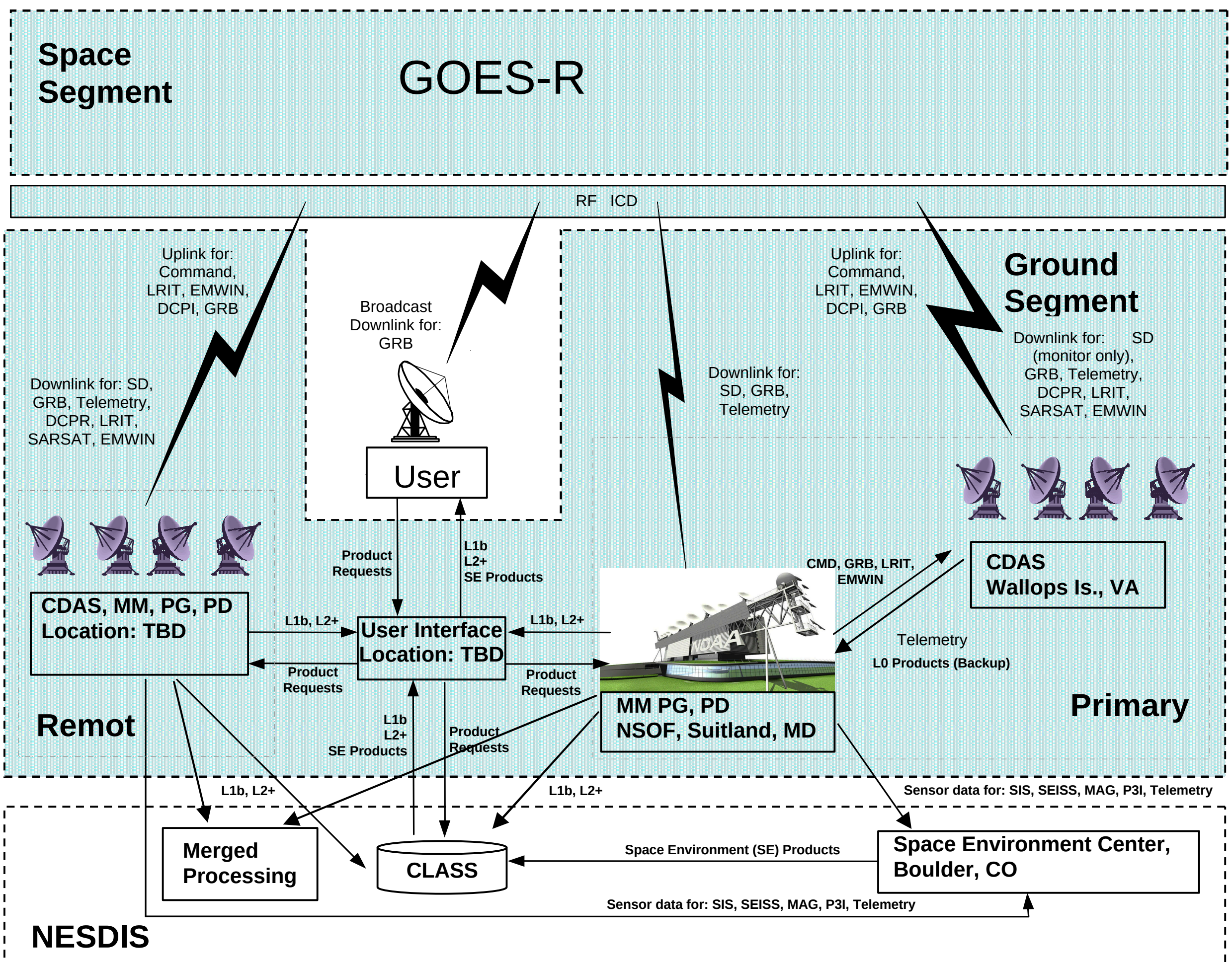


Figure 1-1. GOES-R System Overview Indicating the Portion of the System for Which the Prime Contractor Will Be Responsible

For simplicity, the following items are not explicitly shown in Figure 1-1: instruments, Integrated Logistics Support (ILS), enterprise management and the NESDIS infrastructure interface. It is understood that a complete set of instruments will be located in each operational orbit. The ILS, enterprise management and NESDIS infrastructure functions are discussed in Section 3.

The Ground Segment will operate from three operational sites. The NOAA Satellite Operations Facility (NSOF) will house the primary mission management (MM), product generation (PG), and product distribution (PD) functions, with MM support from the Wallops Command and Data Acquisition Station (CDAS). The third site at *TBD* will house the CDAS, MM, PG and PD functionality and be concurrently operated remotely from the NSOF. This remote site location will have visibility to both operational satellites and spare satellite(s) on-orbit locations.

The CDAS will transmit commands, "global rebroadcast data," and unique services to the satellites, and ingest telemetry and instrument data. The product generation function will produce all Level 1b and Level 2+ products except for the Solar Imaging Suite (SIS) and the Space Environment In-Situ Suite (SEISS) instruments. The products from these instruments will be produced by the National Weather Service (NWS) Space Environment Center (SEC).

Long term storage is provided by the Comprehensive Large Array-data Stewardship System (CLASS). CLASS is not a part of the GOES-R Ground Segment, but will provide archival services to GOES-R. Level 1b and selected Level 2+ products will be transmitted to CLASS, through the NESDIS infrastructure interface, for archive and distribution to archive users.

There are a number of dependencies between the space and ground segments that need to be resolved during the Program Definition and Risk Reduction (PDRR) phase. How these dependencies are resolved will influence this concept of operations. For example:

- The size of the orbital stationkeeping box could determine the number of antennas per orbital location needed to operate the system.
- By decreasing the size of the orbital box from ±0.5° to ±0.05° and using more frequent maneuvers, it may be possible to operate during station keeping – this could affect the amount of fuel required and the design approach (for instance types of thrusters).
- Automated operations to be performed on-board the satellite – e.g., if the satellite has the capability to perform on-board orbit determination, it may be possible to perform routine station keeping and some flight operations related to health and safety of the satellite on board without ground supervision or intervention.
- Distribution methods for GFUL (i.e., the totality of Level 1b products) – decisions to distribute GFUL via a GOES-R satellite link impacts the communication requirements of the system architecture.

1.3 Document Scope

The purpose of this Concept of Operations (CONOPS) document is to specify how the GOES-R system will be operated. The document will be updated and modified as the GOES-R procurement process evolves, and again as the GOES-R series design and system architecture matures.

A representative operational documentation tree is illustrated in Figure 1-2. This CONOPS is based on the GOES-R Program Requirements Document (GPRD). It influences both the MRD and is influenced by them. Together with the MRD, this concept of operations is used as a reference for the system design. Detailed operations plans and procedures, user guides, and maintenance plans and procedures will be based on the system design.

The document tree may vary slightly for the instruments because they are being procured by NASA, and are in various life cycle phases. For example, the ABI development contract has been issued. This contract is based on a Technical Reference Document developed by NASA from the MRD.

The concept of operations is a living document in the sense that (i) it will be modified as a result of analyses conducted during the PDRR phase, and (ii) concepts related to individual system components will be added or modified as a better understanding of these components is obtained. It is expected that the detailed system design will implement the concept of operations, as it exists at the end of the PDRR phase. It is recognized that the concept of operations might need to be modified to accommodate concepts embedded in commercial off-the-shelf (COTS) components included in the design.

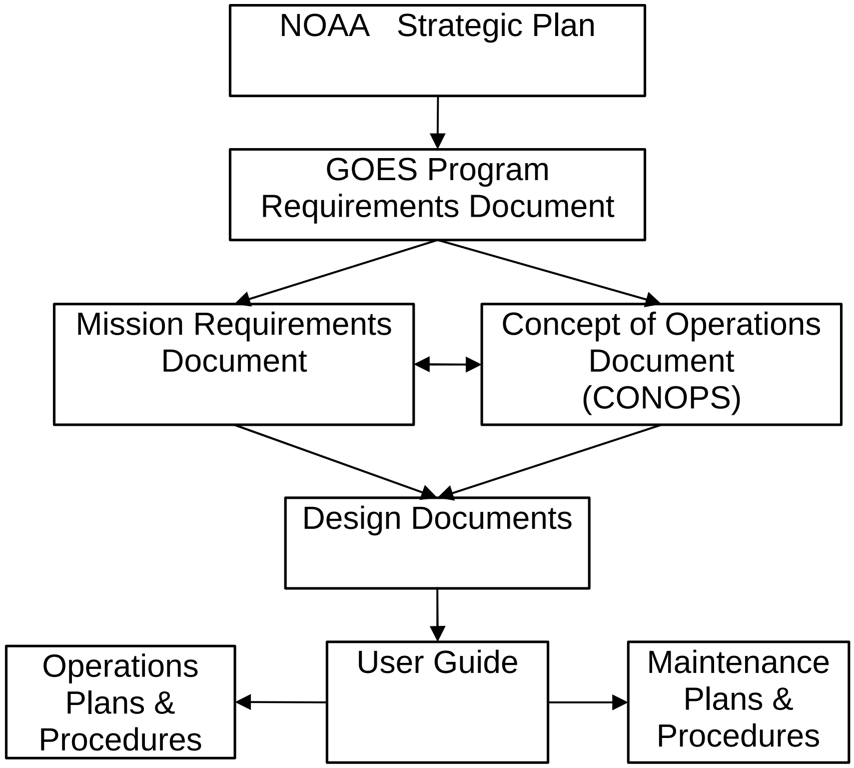


Figure 1-2 Representative Operational Documentation Tree for GOES-R System

2 GOES-R System Concept

In this section, the GOES-R system concept is discussed from the perspectives of overarching operational philosophy, mission goals, a high-level view of the GOES-R space and ground segment, and the GOES-R interfaces. The functional view of GOES-R operations is discussed in somewhat greater detail in Section 3. The operational concept is further defined in Section 4, where various system data threads are presented.

2.1 Overarching Operational Philosophy

The GOES-R system operations concept is based on the following three principals expressed in decreasing order of importance:

1. Launch and operate the spacecraft safely.
2. Acquire and disseminate all available spacecraft telemetry and instrument data.
3. Given the first two items, operate as efficiently as possible. Efficiency is measured by the cost of achieving these activities within the latency requirements specified in the MRD.

These principles form the foundation on which the operational system will be built. Each facet of operations will address these priorities.

Objectives are derived from these principles and are applied throughout the system. Derived overall objectives include:

1. Operational staff will quantify, assess and justify all identified operational risks and implement safety enhancing measures.
2. A training program will be in place to train and certify new operational staff members. This training program will also be used for regular operational staff refresher training and recertification.
3. Operational experience will be incorporated into system upgrades and maintenance procedures.
4. System upgrades and maintenance will be performed with minimal interference to operations. Whenever practical, system upgrades and maintenance should be done on a non-interference basis.
5. All satellites will be maintained within a predefined stationkeeping box.
6. Historical and real-time State Of Health (SOH) data will be continuously archived and made available to operational staff. These data shall be available on-line to operational staff.
7. Mission management, product generation and product distribution activities will be scheduled and optimized for efficient utilization of resources
8. Satellite and network operation emergency and contingency procedures will be available on-line to any system workstation.
9. Autonomous operations will be implemented whenever they are deemed safe, feasible and cost effective. No autonomous operation will be exercised until it has been validated.
10. Enterprise Management will be implemented across the system. For example, when a significant event is observed autonomously, it will be logged and appropriate operations and maintenance staff will be notified.

2.2 GOES-R Space Segment

The following spacecraft and payload system description reflects current concepts and will be updated throughout the GOES-R program development.

GOES-R Spacecraft: Fully redundant, 3-axis stabilized bus with an on-orbit lifetime of 15 years – 5 years of on-orbit storage and 10 years of operational life. Additionally, the satellites may be stored on the ground for up to five years. The GOES-R mission orbit will be geosynchronous at 75°W and 135°W. The primary instruments have growth contingency specified in their contracts. The spacecraft bus will support the various selected payloads, with approximately 25% growth contingency for other instruments, communications and other bus components. Other bus components include propulsion, attitude determination and control, telemetry, tracking and command, magnetometer, data handling, thermal, communications, power, mechanisms, error detection and correction, and structure.

GOES-R Baseline Payloads: Advanced Baseline Imager (ABI), Hyperspectral Environmental Suite (HES), Solar Imaging Suite (SIS), Space Environment In-Situ Suite (SEISS), Geostationary Lightning Mapper (GLM), Global Rebroadcast (GRB), Unique Payload Services for Emergency Managers Weather Information Network (EMWIN), Low Rate Information Transmission (LRIT), Search and Rescue (SAR), and Data Collection System (DCS). The primary mission instruments are the ABI and HES.

Launch Criteria: TBS

2.3 GOES-R Interfaces

Operational interfaces for GOES-R include:

1. Instruments to Spacecraft Bus (ABI, GLM, HES, SEISS, SIS)
2. Space Segment to Ground Segment (TLM, CMD, GRB, GFUL, DCS, SAR, EMWIN, LRIT)
3. Ground Segment to Users
4. Ground Segment to NESDIS Infrastructure

2.4 GOES-R Ground Segment

The GOES-R Ground Segment is functionally partitioned into mission management, product generation, product distribution, NESDIS infrastructure and integrated logistics support (ILS). The GOES-R MRD also specifies a User Interface function; instead of being discussed separately, this function is integrated into the applicable sections in the CONOPS.

A high-level partition of the GS functionality is illustrated in Figure 2-1. To provide an understanding of these functions, some typical activities for each function are provided in Table 2-1. Functional descriptions are described in Section 3. Selected functional elements for operations at the SOCC and CDAS are represented in Appendix A.

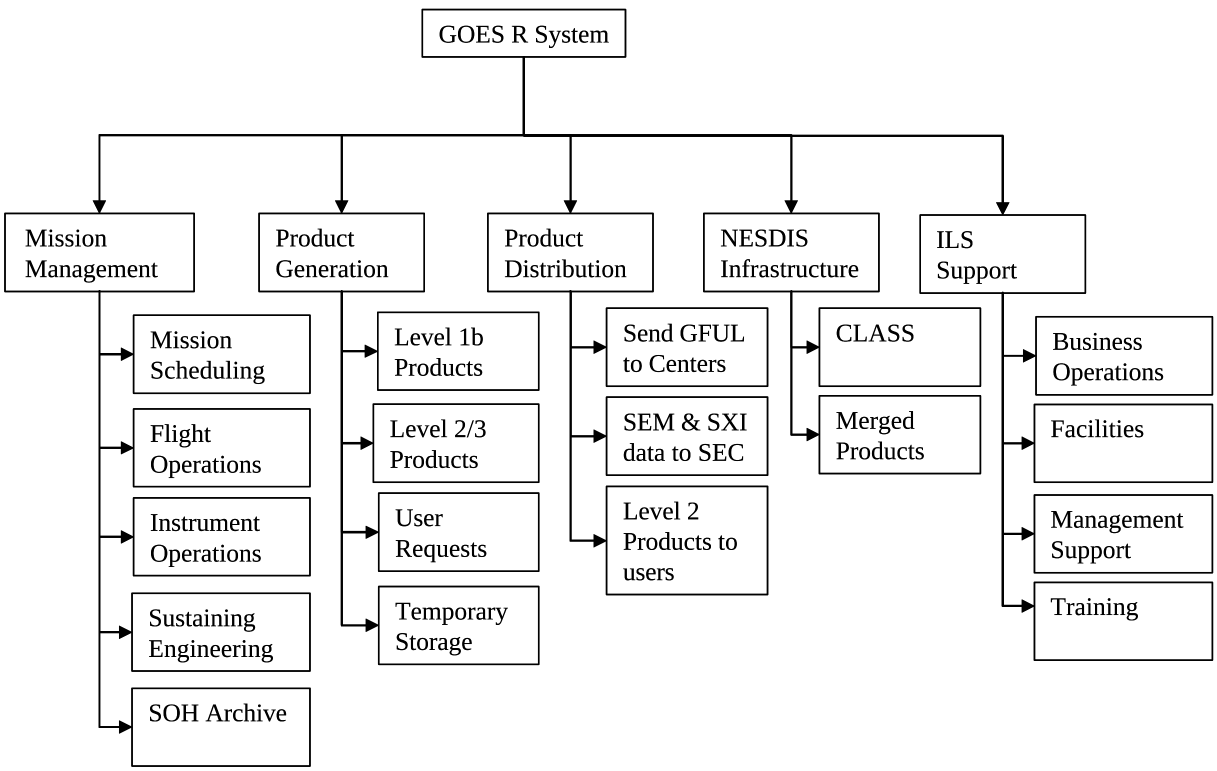


Figure 2-1 Functional View of the Ground segment

Table 2-1 Description of Selected Subfunction Activities

Function	Subfunction	Description
Mission Management	Flight Operations	Capture of telemetry from spacecraft
Mission Management	Flight Operations	Processing captured telemetry to engineering units.
Mission	Flight	Transmit and capture ranging signals from the satellite

Function	Subfunction	Description
Management	Operations	
Mission Management	Flight Operations	Capture instrument data and perform processing to form Level 0 data.
Product generation	Level 1b products	Monitor Level 1b processing to insure that data processing requirements are met.
Product Distribution	GFUL distribution	Level 1b data is transmitted to operational users via commercial satellite, ground lines or a GOES-R satellite.
Product generation	Temporary Storage	Store Level 0 data for 30 days and raw data records for 3 days.
Mission Management	Flight Operations	Format and transmit commands to spacecraft including • Scripted sets of commands • Single commands • Bit-level commands from command mnemonics
Mission Management	Flight Operations	Display telemetry data in a form that can be interpreted by controllers and engineers using graphics, tables, run charts or raw engineering data.
Mission Management	Multiple Subfunctions	Monitor spacecraft State of Health (SOH). Determine when commands are needed and format and transmit commands according to a set of automated rules from the script library. This system will be used for routine operations and for well-understood workarounds and anomalies. Elements of this system may also reside in CDAS to improve response time for commanding.
Mission Management	Flight Operations	Control commanding and ranging functions remotely from the SOCC; remote operation of CDAS
Multiple (product generation and distribution)	Multiple subfunctions	Control processing of instrument data to Level 0 from the SOCC. This system also interfaces with the product monitor and receives the results of its analyses; Remote operation of Instrument Processing
Mission Management	Operations Scheduling	Prepare command schedules based on User Requests, Maneuver Plans, Orbital events, and other special operations, as needed, and apply rules to generate command loads. Using the Command Interpreter and the scripting function as needed, generate an integrated command load.
Mission Management	Flight Operations (Optimize System Design)	• Perform reliability analyses • Perform failure analyses (assess failure modes and consequences; develop contingency plans and mitigation approaches) • Assess, develop, test and implement automation approaches
Mission Management	Instrument Operations	Determine the spacecraft orbit using data from ranging functions. Provide predictions for eclipse and other on-orbit events to Mission Planning and Users as needed.

Function	Subfunction	Description
Mission Management	Flight Operations	Plan maneuvers based on orbit determination (OD). Provide inputs to Mission Planning to schedule appropriate commands to execute the maneuver.
Mission Management	Instrument Operations	Using OD products, provide instrument FOV and safety constraints to mission planning for inclusion in the command load.
Mission Management	Instrument Operations	Receive ranging data from the spacecraft and process for use in OD.
Mission Management	Flight Operations	Monitor spacecraft and generate commanding scripts and/or single commands to insure that the satellite is functioning safely. Generate operations reports describing the overall performance of the spacecraft.
Mission Management	Flight Operations	Perform real time trending, fault detection, and notification as required. Monitor S/C telemetry for trends. Include out-of-limit alarms and perform standard statistical test to determine anomalous behavior (even if the parameter is within limits). Use these data to detect specific faults.
Mission Management	Instrument Operations	Monitor instrument and ensure minimal degradation and maximum functionality for the life of the instrument. Generate operations reports describing the overall performance of the instrument.
ILS	Maintenance	Maintain ground segment hardware and software so that they provide effective command, control, data capture (instrument and spacecraft), data and command transmission and orbit determination functions for the life of the spacecraft. Track statistics on GS operations, performance, reliability and availability.
ILS	Replenishment Planning	Ensure that the system can be upgraded and replenished every 7 years at a minimum while providing for maximum input and feedback for operations during development and test and a minimum effect to operations during implementation.
ILS	Technical Documentation	Maintain (to include updating) system engineering drawings and electronic technical documentation for operations and maintenance for the life of the system.
ILS	Training	Ensure that system and segment level (to include algorithm usage) training is developed, maintained for operations and maintenance for the life of the system.

3 Functional View of Operational Concepts

This section is organized in accordance with the functions specified in Figure 2-1, including the cross-cutting function, Enterprise Management. The huge difference in processing and communications requirements between GOES-R and earlier GOES series necessitates a substantial increase in bandwidth, processing capability, and dissemination approaches. For example, in the earlier systems, the entire Level 1b set is rebroadcast as GVAR data. Due to the large increase of data, in GOES-R the entire set of Level 1b data is called GFUL and is distributed to key users. A subset of this data, called GRB, is transmitted to the GOES-R satellite for rebroadcast to all users. A comparison of the GOES-R throughput and storage requirements to previous systems is given in Table 3-1.

Table 3-1 Comparison of Processing and Storage of GOES-R Series to GOES I - P

	GOES R	GOES I-P
Instrument Data Downlink	132 Mbps	2.1 Mbps
Rebroadcast	5 – 24 Mbps	2.1 Mbps
Level 2/3 Products	1.5 Gbps	< 4.7 Mbps[1]
Product Latency	Real-time to 5 minutes (product dependent)	Real-time to TBS minutes
Number of Types of Products	>160	41
CLASS Data Storage	Daily: 0.5 TB 7 year life: 1,100 TB	N/A
Temporary Storage	30 Days of L0 and 3 days of Raw Data Records	0 days

[1] This value was determined by backtracking from the GOES-R estimate. GOES I-P has ¼ the number of types of products, ¼ the resolution, and ⅕ the scan coverage. Thus the number is derived by dividing the GOES-R estimate by 80. This is a conservative comparison. Estimates generally range from a factor of 80 to 120 when comparing the two.

Because of the complexity of and the amount of data being generated by GOES-R, automation is emphasized in each of the functional discussions. Automation ranges from product generation to remote control of antennas and remote software maintenance. Instrument processing is already heavily automated, and the goal will be for full automation of day-to-day GOES-R processing. Some areas of automation will cross functional boundaries. For example, it might be possible to autonomously, dynamically task the instruments based on automated analysis of weather products. Staff will be needed for development and testing of new algorithms, troubleshooting algorithms and equipment, calibration, and sustaining engineering.

Though this CONOPS does not identify specific cross-functional automation, or specific technologies (like artificial intelligence or automatic knowledge discovery), the GOES-R concept of operations encourages cross-functional automation. The key criterion for automation is satisfaction of the overarching philosophy mentioned in Section 2: safety, product generation, and efficiency in that order.

Availability requirements in the GOES-R MRD drive the operational concept to include:

- A consolidated remote facility at a site that is visible to the operational and spare GOES satellites

- The remote facility is far enough from the Wallops CDAS and Suitland SOCC to avoid events that would be catastrophic to either of those sites

- Concurrent operations at the primary and remote site so that no data is lost should the primary site go down.

In the ensuing paragraphs, the CONOPS focuses on individual functions and subfunctions. Understanding this discussion might be enhanced by periodically referring to the system overview given in Figure 1-1 and the threads given in Section 4. Terms referring to people, like *flight operations team* or *mission manager*, are occasionally used. For these cases, it is assumed that the program is organized functionally so that the organization chart would be identical to the functional chart.

3.1 Enterprise Management

The Enterprise Management function is responsible for monitoring, assessing, and controlling (the configuration of) the operational systems, networks, and communications for the entire GOES-R system. The enterprise management function is performed on a 24 x 7 basis. Some specific functions of enterprise management are:

- Monitor the end-to-end performance of all ground segment systems, networks, communications links and antennae operations
- Control all ground segment networks and interfaces to external systems
- Status and maintain all hardware and software configurations attached to the operational networks
- Status and maintain the configuration of all non-operational (i.e., support and test) networks (including the devices attached to them)
- Provide remote software distribution and enable remote software maintenance
- Perform license management (e.g., assuring that the number of active users of a particular application does not exceed what is allowed by the license)
- Assess network and system performance
- Provide Internet metering
- Provide Web based help desk
- Maintain and enforce network IT security within DOC Guidelines

The enterprise management function will work closely with the sustaining engineering function. Though the enterprise management function will monitor and maintain the operational and non-operational systems and networks, actual installation and maintenance of both hardware and software is part of the sustaining engineering function.

The status of the entire ground segment will be continuously available for monitoring from any single site.

3.2 Mission Management

This CONOPS provides a vision of increased automation without defining precisely what automation is expected. The details on what is to be automated will be specified as part of the PDRR phase. Any autonomous operations or automatic processes will be thoroughly tested and validated before they are used for flight operations and in simulators as part of an end to end system testing.

The primary organization responsible for the execution of the mission management function is the Office of Satellite Operations (OSO).

3.2.1 Mission Scheduling

This section discusses mission management for both the Launch and Early Orbit Phase (LEOP) and the on-orbit mission phases (i.e., storage and operation). During the on-orbit phases, mission management personnel will be available on site on an 8 x 5 basis. Whenever people are not on site, a member of the mission management team will be on call. At end of life, the GOES-R will be lifted to a super-synchronous orbit.

3.2.1.1 Launch and On-Orbit Support (LOOS)

This section describes the requisite steps required to prepare for and launch a satellite. It covers preparation of the satellite, launch facilities and ground segment. This function includes three phases: Pre-Launch, Orbit Raising and On-Orbit Tests. Each phase consists of several distinct tasks and each phase has a unique purpose. A GOES satellite is not considered as accepted until it successfully meets the criteria of the Acceptance Plan.

3.2.1.1.1 Pre-Launch

This function prepares the satellite, the launch team, and the ground support team for the launch and for transition to on-orbit satellite operations. The ground support team includes launch and early orbit staff, flight operations staff, instrument operations staff and sustaining engineering staff. This function includes mission planning, end-to-end testing, satellite launch preparations, satellite operations, software preparation and coordination with the ground network functions.

Mission Planning begins during the design and development of the satellite and ends at the final mission meeting prior to lift off. This work is made up of Mission Analysis, Sequence of Events (SOE) development including contingency planning, timeline development, rehearsals, and a launch readiness review. The mission planning function includes:

- Developing a maneuver plan
- Refine daily and seasonal scenarios
- Prepare and simulate contingency operational scenarios
- Deciding upon a launch window
- Identifying and obtaining the necessary resources
- Developing a sequence of events
- Developing a timeline

- Launch pad communications testing
- Conducting launch rehearsals

End-to-end testing is an integral part of launch preparations.

Launch preparation may also include employing an independent Mission Assurance Team (MAT). The MAT would assure the completeness of checklists, plans, and tests, and would review test results for adequacy. The MAT may also perform physical inspections to assure that the satellite and launch vehicle are ready for launch.

3.2.1.1.2 Launch and Early Orbit Tests

Mission execution is realized through the execution of a planned Sequence of Events (SOE) and Contingency Plans, if required. Each Launch Mission is unique; however, several tasks can be generalized. These tasks include:

- Execute Launch Mission SOE – This SOE begins typically 2 to 4 days before liftoff and ends after the transition to normal on-orbit configuration and final deployments. This process encompasses the time of the highest risk to the satellite life and on-orbit mission. During this process, the subsystem experts track the SOE progress closely and monitor the health of the satellite. If an anomaly condition occurs, the appropriate Contingency Operations Plan (COP) is initiated.

- Activation and Characterization Test (ACT) Phase – The Bus Performance and Health Evaluation Process is achieved through planning and performing a test sequence that verifies the satellite's performance. Following the testing, a test report is generated. The satellite's health is monitored continuously during this period. This function typically lasts about 10 days.

- System Performance and Operational Test (SPOT) Phase – Instrument performance is extensively tested and calibrated before they are declared operational. These tests are end-to-end. These activities include:

    - Functional tests of all physical controls including heaters, doors, and motors
    - Diagnostic tests of each instrument's performance including operation of any modes
    - Calibration of radiometric performance
    - Computation of space environment sensitivity
    - Initialization and tests of instrument dependent ground software
    - Algorithm performance tests
    - System performance tests
    - End product evaluation
    - Technical Documentation Verification

3.2.1.2 Operations Phase

After the SPOT phase, the satellite is generally in a storage location. Periodic end-to-end testing (including SPOT testing) will be preformed during this period. This testing will also be performed prior to maneuvering the satellite to another location, such as the normal operational orbit.

Mission management is responsible for receiving tasking requests, resolving conflicts that might occur and scheduling instrument and satellite operations. This tasking comes from primary operational and NOAA supported science users, such as the National Weather Service, Air Force Weather Agency (AFWA), and co-op science development entities.

Mission planning will be largely automated. Users with authority to request special coverage will normally make requests using a web-like interface, but they shall also be able to request tasking by direct contact (e.g. by e-mail) with the mission manager. These requests will be merged using the mission planning scheduler. The schedule will then be de-conflicted and a timeline generated. This timeline will take into account resource constraints.

The mission planning system will accommodate quick response tasking, such as severe weather, by dynamically modifying the operational schedule.

Once a schedule is generated, it is converted into a command table for uplink to the satellites for on-board schedule execution.

3.2.1.2.1 Scheduling instrument operations

After SPOT, periodic end-to-end testing will be performed while satellites are in the storage location. This testing will also be performed prior to maneuvering to another location. It is planned that all instruments will operate concurrently and continuously with minimal (i.e. less than two 10-minute periods per day - TBD) downtime for housekeeping.

ABI Operations

The ABI will perform the following functions:

- **Full Disk Imaging (FD) –** This task provides hemispheric coverage of the area up to 65° local zenith angle. The coverage rate is either 15 or 5 minutes depending on the instrument operating mode. The spatial resolution is 0.5 to 2 km over a spectral range of 0.47µm - 13.3 µm (across 16 discrete channels).

- **Severe Weather/Mesoscale (SW/M) –** This task provides better temporal resolution, but over a smaller area. The coverage rate is 1000 km x 1000 km in 30 seconds. The spatial resolution remains 0.5 to 2 km over a spectral range of 0.47µm - 13.3 µm (across 16 discrete channels

- **Continental United States (CONUS) –** This task provides timely coverage over the continental US. The coverage area of 3000 km (N/S) x 5000 km (E/W) is performed every 5 minutes. The spatial resolution remains 0.5 to 2 km over a spectral range of 0.47µm - 13.3 µm (across 16 discrete channels)

ABI has two imaging modes: Mode 3 and Mode 4. Modes 1 and 2 are less capable modes that are no longer operationally envisioned.

- Mode 3 – Provides a full disk image, three CONUS images, and 30 mesoscale images across all 16 channels every 15 minutes.
- Mode 4 – Provides a full disk image across all 16 channels every 5 minutes.

Operational scenarios are TBS.

HES Operations

The HES will perform the following functions:

- **Full Disk Sounding (DS) –** This mode provides hemispheric coverage at the rate of 62°local zenith angle in one hour, which is about 7 x 10^7 km^2. The IR spatial resolution is 10 km over a spectral range of 3.7µm - 15.4µm (non continuous).
- **Severe Weather/Mesoscale (SW/M) –** This mode provides a better special resolution, but over a smaller area. Specifically, the IR resolution is 4 km over the range of 3.7µm - 15.4µm (non continuous). The coverage rate is 1000 km x 1000 km in 4.4 minutes.
- **Coastal Waters (CW) Imager –** This mode provides visible and near IR data. It can provide coastal or ocean area coverage within 400 km of the US coast and Hawaiian Islands in less than three hours. The visible spatial resolution is less than 300 m over the spectral range of 0.4 µm - 1.0 µm. Coverage of land regions can also be provided at this rate.

Each HES must perform either the DS task or the SW/M task, covering regions specified to the ground segment. The CW task is performed concurrently with either of the other two tasks. The DS and SW/M tasking inputs will come from other instrument observations and model outputs predominantly if not exclusively. The SW/M mode will be used to characterize the clear air in advance of storm systems observe the evolution of storms.

Operational scenarios are TBS.

SEISS, SIS, GLM and other payload Instruments Operations

The GLM will provide constant coverage of the full disk, detecting lightning events. Any necessary housekeeping will be scheduled.

The SEISS will provide constant coverage of the particle flux in the geo environment of GOES. Any necessary housekeeping will be scheduled.

The SIS will provide constant coverage of the sun x-ray imagery, x-ray total flux and extreme ultraviolet. Scheduling will be coordinated with SEC and SOCC. Any necessary housekeeping will be scheduled.

Operational scenarios are TBS.

3.2.1.2.2 Scheduling Flight Operations

Mission planners will schedule tasks needed for flight operations. All non-science data gathering operations will be executed in less than two 10-minute periods per day (TBD).

These non-science data gathering operations include the following:

- *Eclipse Operations* – once each equinox period.
- *Stationkeeping* – including time necessary to re-establish INR within required accuracy.
- *Special Instrument Calibrations* – generally performed autonomously within normal instrument operation, special calibrations may be requested for engineering or science needs.
- *Solar and Lunar Intrusions* – Planning will take into account solar and lunar intrusions into instruments, instruments and ground antennas. In the case of ground antennas, planning may take advantage of the remote site to avoid intrusions.
- *Maneuvers* – Mission planning schedules satellite maneuvers from the storage location to an operational location, and if needed to a new location. At end of life, mission management schedules relocation to a supersynchronous altitude.
- *Housekeeping Events* – Routine activities will be scheduled to minimize outages.

3.2.2 Flight Operations

The concept for flight operations is discussed in terms of its major functions: commanding, state-of-health activities, and flight dynamics.

3.2.2.1 Commanding

The flight operations function converts scheduled operations created by mission planning into commands. This function will be achieved in an automated or semi-automated fashion whenever possible. The resultant command sequence is validated for correctness via a simulator. Assuming that no problems are detected, the command sequence is uploaded to the satellite.

Specific approaches to commanding depend on both ground and satellite automation approaches. Most command rules and sequences are uploaded and stored on board. These on board command sequences are then executed either as directed by the ground or in response to on board, rule-based analysis of SOH telemetry data. SOH telemetry will be analyzed automatically on the ground. Potential applications suitable for this automated commanding may be momentum management, maneuvers, and fault detection and correction (FDC). The function will provide operator awareness of any automated commanding.

The command upload will enable autonomous payload operations for TBD days.

The flight operations staff will also be able to generate commands manually. The command system interface will be a state of the practice graphical user interface.

In addition to uploading commands, the flight operations function will upload software, generate and load spacecraft and instrument databases. On-board software and databases will be periodically checked to assure their validity.

3.2.2.2 State of Health (SOH)

On-orbit SOH operations begin upon completion of spacecraft testing and continue until end-of-life. It includes monitoring satellite health, recovering from anomalies, monitoring and managing on-board software and other housekeeping operations. The primary functions of this activity are to assure satellite safety and maximize satellite mission life.

This function will enable operators to determine whether on board components are operating within limits. This can be achieved using various techniques, such as displaying control charts. It will normally be unnecessary for operators to be looking at raw data (expressed in engineering units) but that data will be available in real-time or for playback if desired. The system is expected to autonomously analyze the data in accordance with operator and engineer specified rules, control limits and standard statistical tests. This function will automatically notify an operator whenever one of these rules, limits or tests is violated.

SOH data is stored for the life of the satellite. It includes data obtained during box testing and end-to-end testing so that operations can determine whether any specific anomaly has previously occurred.

Flight operations will be 24 x 7, but engineering support is available on site on an 8 x 5 basis. In the event that engineering support is needed when people are not on site, support personnel will be on call.

Other activities included as part of this SOH function include managing on-board environment and resources including thermal and power systems, and consumables.

Flight operations will be able to retrieve and analyze historical information. Telemetry data may be replayed and excursions performed. Each of these activities will be done without interfering with operations.

3.2.2.3 Flight Dynamics

Flight dynamics includes orbit and attitude determination, stationkeeping/maneuver planning and recovery, and collision avoidance.

Even if the orbit is determined on-board and is adequate for Image Navigation and Registration (INR), flight operations will determine the orbit using ranging as a backup (TBD). Either ranging or the orbital position specified in telemetry will be used for ground antenna pointing during maneuvers.

Nominal flight dynamics tasks are:

- Obtain orbit and attitude determination data
- Perform orbit and attitude determination
- Generate pointing data for the ground station antennas
- Update eclipse, and celestial body interference predictions
- Generate star tracker data for uplink via command or software load
- Predict station-sun interference
- Plan, execute and evaluate maneuvers and burns

Although collision avoidance is not normally a significant issue during operations within the assigned station box, free-drifters, debris and relocated spacecraft may become threats, and must be monitored. Collision avoidance will take on additional significant during station relocation activities and when the spacecraft is in the 105 degree West equilibrium point.

3.2.3 Instrument Operations

The instrument operations function interacts with the mission planning function to assure proper instrument performance. This instrument operations function assesses instrument field of view and safety constraints as part of its validation of scheduled operations.

Orbital dynamics, determined by the flight operations function, are an input to instrument operations.

This function determines the health of the instruments, when the sun or moon are within the field of view of an instrument, interaction among instruments, potential for environmental contamination and any other hazards that might affect the instruments. The purpose of this function is to maximize the life of the instruments.

Instrument operations will assess the quality of products and the need for calibration.

This function interacts with the flight dynamics function by providing rules for operating the instruments during yaw flips, eclipse periods and other special circumstances. Instrument operations will also work with flight dynamics to evaluate INR accuracy to determine whether instruments can be operated during maneuvers and, if not, when it is appropriate to start instruments operations.

Personnel implementing instrument operations will select operational modes as needed to handle health and safety monitoring and anomalies. They will also work with engineering support to determine rules of operations for inclusion in training courses and for potential automation.

The instrument operations function will validate all automation related to the instruments before the automation is permitted to become operational. The ground segment personnel will work with the space subsystem personnel to determine whether it is feasible to dynamically task space assets and autonomously transform meteorological data into information for fast and accurate decision making.

Instrument operations will generate reports related to instrument performance. These operators will work with engineering support to determine what statistics are necessary to collect.

3.2.4 Sustaining Engineering

3.2.4.1 Spacecraft Engineering Support

Spacecraft engineering will provide engineering expertise needed to ensure spacecraft health and safety and to maintain a continuous flow of high quality mission data. This support includes, but is not necessarily limited to: engineering analysis, including real-time assessment and long-term trending of the performance of all spacecraft and subsystems; anomaly investigation and resolution; maneuver planning and execution; and engineering procedure and database development and maintenance.

3.2.4.2 Instrument Engineering Support

Instrument engineering will provide engineering expertise needed to monitor instrument performance and detect, diagnose and resolve instrument anomalies. Instrument performance analysis will be performed by evaluating significant instrument performance parameters, analyzing short and long term trends, archiving all pertinent data for future use, and performing statistical analysis of data pertaining to instrument radiometric calibration and performance.

3.2.4.3 Ground Segment Support (Maintenance, Upgrades, Installation)

This function is responsible for installing, monitoring, testing and maintaining all GOES-R ground segment hardware such as the command and control system, processing and distribution system hardware, IT equipment and communications equipment. The precise way that this will be done depends on the system architecture. The maintenance and installation process will be compatible with the property management process.

3.2.4.4 Software Support (Maintenance, Upgrades, Installation)

This function is responsible for installing, monitoring and maintaining all GOES-R software, databases and processors. This software includes IT software, operational ground software, and on-board software. On-board software is generally modified only to mitigate errors found in the course of operations. Standard procedures for software patches are developed and tested prior to launch. Prior to uplinking a patch, the software patch is loaded to the simulator on the ground and thoroughly tested. All uploads will be tested, loaded and integrated on a non-interference basis.

Under special circumstances, on-board algorithms may be improved. Before new algorithms are transmitted to the satellite, they will undergo rigorous test procedures similar to the standard procedures developed for patches.

As part of regular monitoring of the on-board software, the entire contents of the memory are downloaded and verified. Memory uploads are checked with the ground image before uploading to the satellite.

The software support function includes operations and maintenance of all ground software. This activity is generally concentrated on monitoring and maintaining operations; however, software may also be developed to make the operations more efficient. As in the case of on-board software, all operational software must follow the standard procedures and rigorous testing.

Defined software processes will be used and data on how well these processes perform will be collected. The process data will then be used to improve software processes. Data collection and process improvement is a continuous activity. How well software processes perform and improvement to these processes will be reported to management at regular (typically monthly) intervals.

All of the software will be maintained from a central facility. In the event of a problem, this software maintenance facility will be able to remotely access and inspect the affected component(s). The facility will be able to ingest data from the problematic components to assess the anomalies. When the problem is resolved, the maintenance facility will be able to modify and test the code, and then download it to the appropriate portion of the system.

Potential software upgrades and new programs will be evaluated. When the decision is made to use either new or an upgraded version of software, the software will be tested prior to installation. No operational software will be introduced to the operational system until after it has been thoroughly tested using operational data in a high fidelity simulation environment.

3.2.4.5 Generate Schedules for Routine Support

The sustaining engineering function interacts with the mission management function to assure that routine support does not interfere with operations. Nominally up to a week of daily schedules will be available.

3.2.5 SOH Archive

This function archives all SOH telemetry data for the life of the GOES-R program. In includes normal data base functions, allowing maintenance engineers to access the archive, search for needed data, retrieval of data, and trending analysis. The database and archive will be managed by the enterprise management function and maintained by the maintenance function for the life of the satellite.

3.3 Product Generation

The product generation function creates Level 1b and Level 2+ products. These data are distributed to the appropriate users (by the distribution function) and archived (by the archive function). Based on a set of pre-specified rules, product generation creates subsets of Level 1b data and specific products for transmission to GOES West and GOES East for rebroadcast. These data are called GRB data. Product generation is a real-time function.

The product generation function will provide temporary storage for 30 days of Level 0 data and 3 days of raw data records. These data will be over-written as new data arrives and the temporal requirement has been satisfied.

Product generation personnel will work with the instrument operators and support engineers to assure quality products, detect quality problems and to resolve them. These personnel will also work with scientists to mitigate algorithm and performance deficiencies, and to convert scientific algorithms into operational code.

The system prime is responsible for the success of operational algorithms for product generation and delivery. Algorithm development and software support for product processing will be a collaborative process between the system prime and the government. The NESDIS Office of Research and Applications (ORA) will support algorithm selection, provide test data sets, and serve in an algorithm verification role.

The government will be responsible for the development, test and operational performance for merged platform products (outside the GOES-R system scope) and external product interface processing.

Under some circumstances, the government might need to recalibrate specific instruments and regenerate some products. In this event, scientists will make requests to product generation to regenerate specified products.

Operations performance, instrument calibration performance and associated documentation accompanying changes will be provided for the User Interface segment.

During operations, Level 1b and Level 2+ products will be generated in the Product Generation function by the Office of Satellite Data Processing and Distribution (OSDPD).

3.4 Product Distribution

The distribution function will provide for the transfer of:

- GFUL data to selected government processing centers
- Space environmental data (from the SIS and SEISS) to the NWS Space Environment Center
- Level 2+ products to operational users
- All Level 1b products and selected Level 2+ products to CLASS

Product distribution will monitor that Unique Services information (WEFAX, LRIT, EMWIN, SARSAT and DCP) is transmitted in the correct format. This process will be automated, similarly to the way it is currently done.

The product distribution function will also:

- Transport raw telemetry and product data among and within the NSOF, CDAS, and remote site
- Ensure GRB data distribution

- Route messages to/from the data distribution network

3.5 NESDIS Infrastructure Interface

The NESDIS Infrastructure consists of NOAA systems and facilities needed for GOES-R will be funded by the GOES-R Program Office to accommodate GOES-R resource requirements, but will not be procured as part of the GOES-R acquisition contract(s). These systems and facilities include the Comprehensive Large Array-data Stewardship System (CLASS), Space Environment Center (SEC), and a planned Merged Processing Center.

3.5.1 Comprehensive Large Array-data Stewardship System (CLASS)

The CLASS provides archive and access services for the GOES-R data. CLASS will be operational at two locations, the Space Environment Center (SEC) facility at Boulder, CO and the National Climatic Data Center (NCDC) facility at Asheville, NC. Each facility will have similar hardware and identical software and be capable of assuming the overall CLASS load at any time. During normal operations, both facilities will be operational and share the processing load.

CLASS will archive all GOES-R Level 0 and selected Level 2 products. Users desiring archived GOES-R products request the products through a web interface. This web interface supports all user interactions: user registration, catalog search, data visualization, parsing and submission of orders. CLASS delivers all ordered files either electronically via anonymous FTP or by physical media. CLASS processes orders.

3.5.2 Space Environment Center (SEC)

The Space Environment Center (SEC) will provide product processing for the SEISS and SIS instruments. The GOES-R ground segment will receive the SEISS and SIS instrument data in the sensor downlink and forward these raw data in real-time to the SEC for processing. Products generated from this data will be archived in CLASS for access by users.

3.5.3 Merged Processing Center

The Merged Processing Center provides the capability to produce environmental products based on integrated observational data and products. These observational data and products can be derived from geostationary and polar orbiting satellites, land-based radars, buoys, or any other available sensors. The resultant products generated will be archived in CLASS for access by users. This center will also reprocess GOES-R products as requested.

3.6 Integrated Logistics Support

The GOES-R System Office will partner with industry to provide streamlined, cost effective, and robust GOES-R System support and a viable support infrastructure. The overarching philosophy for the support system is to move the GOES-R System into a state-of-the art support system. The approach is designed to address technology insertion as the system matures. The GOES-R system will have a process to introduce support upgrades prior to part or subsystem obsolescence. This pro-active support solution will provide continuous product improvement while reducing overall support costs.

3.6.1 Business Operations

3.6.1.1 Procurement

All procurement will be part of the ILS function. To the maximum extent feasible, procurement activities will be automated. For example, purchase orders will be tied to the property management system so that there will be traceability from receiving to accounting. This allows invoices to be tied to actual deliveries and purchase orders. As items are received, they will be entered into the property management system – bar coding approaches will be used to minimize manual input. Personnel who perform the sustaining engineering function will be automatically notified of equipment arrival so that they can schedule its installation.

The procurement group will work with the host organization's site facilities manager to negotiate any necessary memoranda of agreement, licenses, or contracts needed to support GOES-R operations. In the case of the SOCC and the Wallops CDAS, existing agreements will be modified to support GOES-R operations. In the case of the remote SOCC/CDAS/PG&D site, this activity will involve significant effort.

The GOES-R system will contain a huge amount of both unique and COTS hardware and software. ILS will use databases to manage licenses and warranties.

3.6.1.2 Plan for Replenishment

Ground segment equipment and software is expected to undergo technological replenishment on seven year cycles. The sustaining engineering group will analyze all equipment and software to determine when it needs to be replaced. A schedule for purchasing new equipment and software, for removing items to be replenished and installing new items or components will be developed interactively between the sustaining engineering function and ILS. Some items, such as desktop computers may be replaced more often than every seven years. Some software packages may be upgraded annually. Other items like antennas may not need to be replaced for 15 years or more, but some of their components may need to be replaced sooner. To whatever extent is practical, the cost of replenishment activities across the life of the GOES-R system will be leveled.

3.6.2 Facilities

The ILS function provides for the GOES-R physical infrastructure. The physical infrastructure includes everything needed to operate the site except for the information technology infrastructure and the antennae. A non-inclusive list of items provided as part of the physical infrastructure is:

- Roads
- Power, including backup power
- Heat and air conditioning
- Environmental services

- All buildings, including operating buildings, warehouses, and storage sheds
- Vehicles
- Physical security at the site
- Construction
- Foundations for antennas
- Facility maintenance (ranging from snow removal to cleaning crews to building repairs)

The GOES-R program will be responsible for assuring that GOES-R infrastructure needs are met. It is expected that the ground equipment will be located at a NOAA facility, at a facility owned by another organization, or both. In either case, the GOES-R program will act as a tenant. Thus the facilities role is primarily a management role – coordinating with the site facility manager rather than managing maintenance crews and other activities performed by a site facility manager. The GOES-R facility manager is responsible for assuring that the site facility operations provides all necessary services. In addition to coordinating with the site facilities manager, the GOES-R facility manager will be responsible for preparing the necessary budget and approving GOES-R specific work.

3.6.3 Management Support

Management support will provide all management data needed by the GOES-R Program Manager. This will be done in compliance with the NOAA Business Operations Manual.

As part of this function, performance metrics, methods for calculating these metrics, action points for each metric (e.g. when a metric goes from "yellow" to "red."), and the actions associated with each metric will be identified. Having determined this information, the management support group will collect the metrics. For those events in which an action point is passed, management support will bring it to the attention of the appropriate people.

3.6.3.1 Property Management

Property management will be performed in accordance with NOAA policies.

3.6.3.2 Configuration Management

Configuration management will be performed in accordance with the GOES-R Configuration Management Plan. Some specific functions included in the configuration management plan are:

- Configuration control
- Configuration audit
- Configuration status
- Problem reporting
- Change request process
- Engineering change notice process

These processes will be automated to the maximum extent practical.

3.6.3.3 Risk Management

Risk management will be performed in accordance with the GOES-R Risk Management Plan. It is intended that risk management will be done proactively, and that this topic will be included in operator training.

3.6.4 Training

Details of the GOES-R Training Program will be established during the PDRR phase, but are expected to include:

1. Both initial and refresher training of spacecraft and instrument engineering and operations
2. All GOES-R routine and contingency operations
3. Ground segment software maintenance
4. Ground segment hardware maintenance
5. GOES-R users
6. Both initial and refresher training

The training will take various forms, depending on the type of training. For example, operators will be trained in facilities that emulate the interfaces and simulate performance with high fidelity. Software and hardware maintenance personnel may receive training from vendors on specific programs or equipment. Users might be able to take synchronous teletraining, or might be able to receive web-based training, depending on their needs.

4 Threads

To thoroughly understand how a system will operate, it is necessary but not sufficient to have a set of threads that trace data through the system. These threads help to characterize and clarify operational concepts. They can also be used during the detailed design of the system to support procedure development and test plans.

The threads presented in this document are solely for illustrative purposes, and are not intended to influence any design decisions.

As the concept of operation evolves and more detail is known about the design, threads can be specified with increasing detail. In this section, three high-level threads are presented. They illustrate:

- The flow of instrument data under normal operations from photons to product generation
- The flow of instrument data from Level-0 records to products
- Commanding

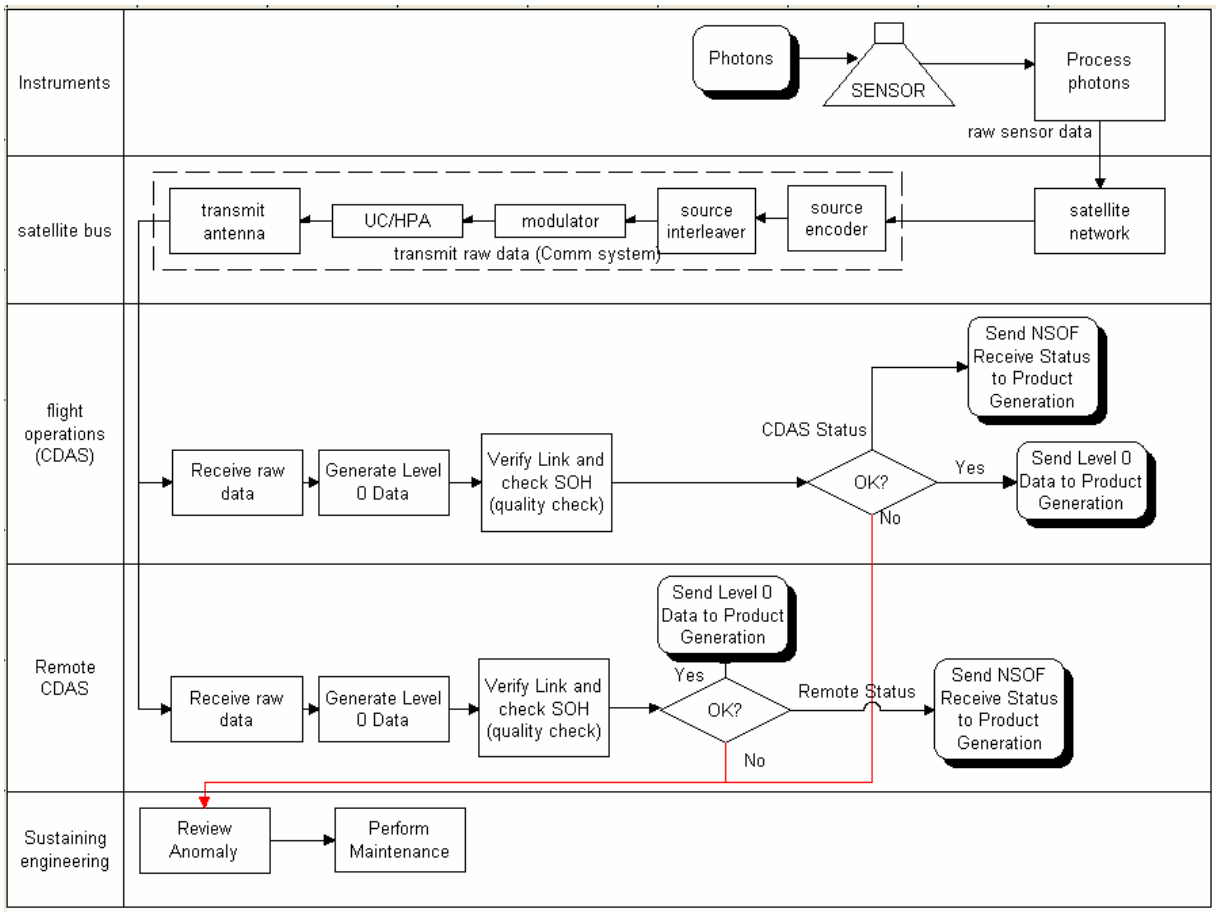
Many other threads are also needed. Some of the *broader* threads need to address issues such as:

- Contingency operations
- Interfaces and support to other agencies; e.g., NASA, Homeland Security and EPA
- Interfaces to foreign sources to exchange environmental data and products
- Distribution of GFUL data to users

4.1 Instrument Data (Normal Operations)

This thread is a top level depiction of the flow of instrument data under normal operations, i.e. when the remote site is simply being used as a backup. Remotely sensed data are detected and processed on board to form raw data records. These data are forwarded via a satellite network to the on-board communications system where it is transmitted via an X-band downlink. The instrument raw data records are received simultaneously at the CDAS and remote site antennas.

In each location a quality check is made on the line to determine whether good data is being received. If not, the group performing sustaining engineering is notified, and they review the anomaly. Generally, this means performing maintenance. Under normal operations, the assumption is that the data at either the CDAS or the remote site is being received correctly and that the data is good. The CDAS will transfer the data to the product generation function. The CDAS and remote site also send an indicator on whether or not its data is good. The NSOF decides which data stream to use. If the CDAS data is good, then (as shown in Section 4.2) product generation will use this stream. Otherwise, it will use the remote site data stream. Under normal operations at least one of these streams is good.



Threads define the way we operate and substantially impact the design. Consequently, alternative approaches need to be very carefully considered.

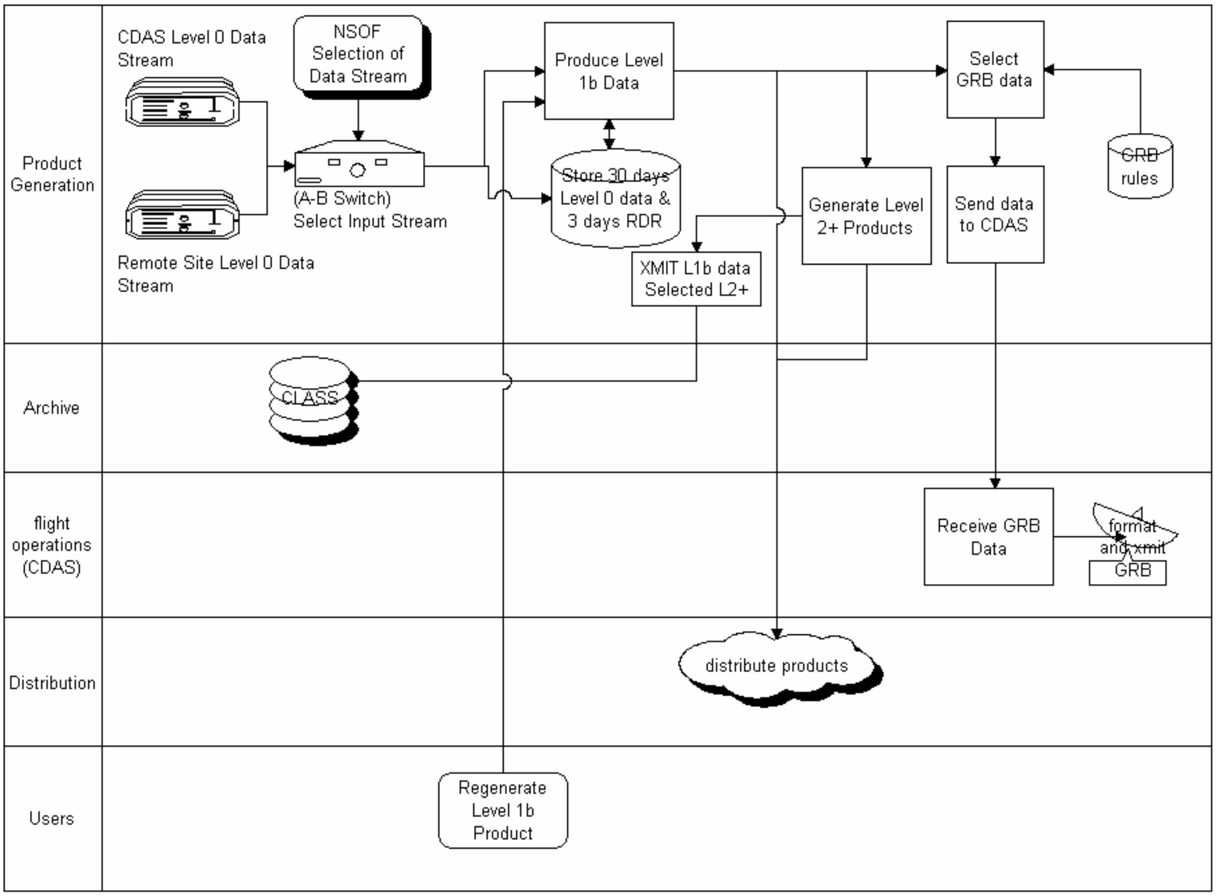
4.2 Product Generation

This thread illustrates the product generation function receiving two streams of Level 0 data and the status information needed to select one of these streams. The selected stream is copied to temporary storage and used to produce Level 1b data. Three days of raw data records and thirty days of Level 0 data are stored. As this temporal data reaches its limit, the data is transferred to CLASS. The transfer process is not shown in this thread.

The product generation function produces Level 1b data in real time. The Level 1b data is then sent to four sinks:

- It is distributed to users as part of the GFUL data set.
- It is distributed to CLASS

- It is used by the “generate Level 2+ products” process.
- It is used by the “Select GRB data” process.



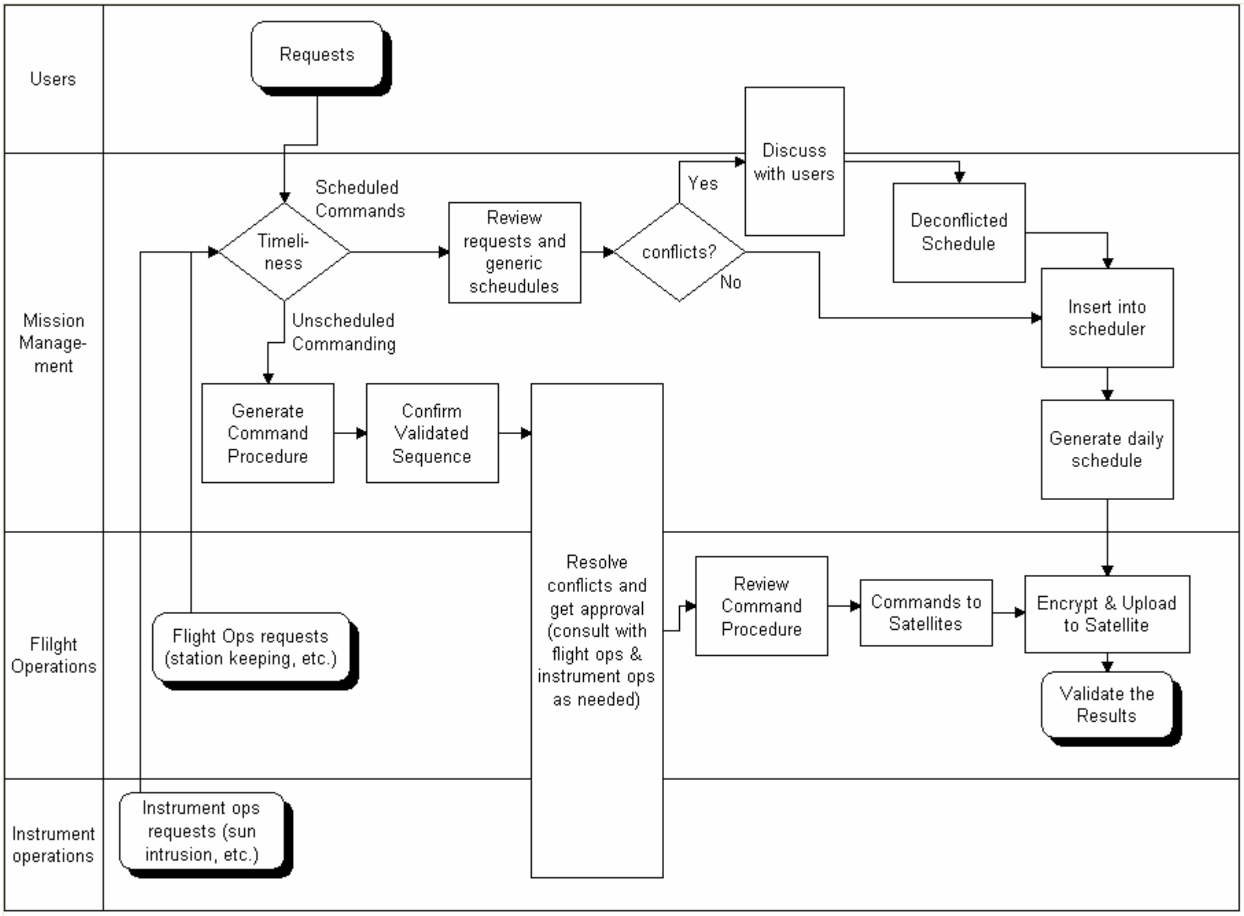
The *Select GRB data* process uses a predefined set of rules to compile a subset of the Level 1b data and Level 2 products for rebroadcast. These data are sent to the CDAS where they are transmitted to the GOES-R satellites for rebroadcast. This process is performed in real-time.

The *Generate Level 2+ Products* process needs to be completed within the latency requirements specified in the MRD.

Note that this is a functional thread and is used only for conceptual purposes. A physical design could have both streams going to a single location for processing, or it could be designed so that each stream is locally processed.

4.3 Commanding

The process depicted in this section is a high level view of commanding. Tasking requests are received by the mission management function, which schedules routine operations at least 24 hours in advance. These operations are reasonably static. Command sequences for various types of tasks are validated and used on a regular basis.



There are other events, however, that require unscheduled commanding. These events could be a reaction to contingency operations, or the need to investigate an anomaly. These events are received from users, flight operations and sustaining engineering. When unscheduled commanding is needed, mission management generates a command procedure. This command procedure is then validated and the resulting command sequence is transmitted to the "*Resolve conflicts and get approval"* process. This process is managed by the mission management function, but includes any needed input from flight operations and sustaining engineering.

Upon approval, the command procedure is reviewed by flight operations. Assuming that it is OK, the commands are sent to the satellite(s). Flight operations validate that command procedures are executed properly by the satellite.

5 Acronym List

AA	Archive and Access
ABI	Advanced Baseline Imager
CDAS	Command and Data Acquisition Station
CLASS	Comprehensive Large Array-data Stewardship System
CMD	Command
CONOPS	Concept of Operations
CONUS	Continental United States
COTS	Commercial Off The Shelf
CW	Coastal Water
DCS	Data Collection System
DS	Disk Sounding
E	East
EW	East West
EHS	Emissive Hyperspectral Sounder
EMWIN	Emergency Managers Weather Information Network
FCC	Federal Communications Commission
FOV	Field of View
GFUL	GOES-R Full Set of Instrument Data
GMS	GOES Microwave Sounder
GOES	Geostationary Operational Environmental Satellite
GLM	Geostationary Lightning Mapper
GOES-R	Next Series of GOES Satellites
GRB	GOES-R Rebroadcast Data
GS	Ground segment
GVAR	GOES Variable Data Stream (Current GOES)
HES	Hyperspectral Environmental Suite
HI	Hyperspectral Imager
I&T	Integration and Test
ICD	Interface Control Document
I/F	Interface
ILS	Integrated Logistics Support
INR	Image Navigation and Registration
IPT	Integrated Program Team
LEOP	Launch and Early Orbit Phase
LRIT	Low Rate Information Transmission
MAT	Mission Assurance Team
MRD	Mission Requirements Document
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NS	North South
NSOF	NOAA Satellite Operations Facility
NWS	National Weather Service

OD	Orbit Determination
PG&D	Product Generation and Distribution
PDRR	Program Definition and Risk Reduction
SAR	Search and Rescue
S/C	Spacecraft
SCOR	Solar Coronagraph
SEC	Space Environnent Center
SEISS	Space Environmental In Situ Suite
SIS	Solar Imaging Suite
SOCC	Satellite Operations Control Center
SOE	Sequence of Events
SOH	State-of-Health
S/W	Software
SW/M	Severe Weather / Mesoscale
T&C	Telemetry and Command
TLM	Telemetry
TTC	Tracking Telemetry and Commanding
UI	User Interface
W	West

6 Appendix A – Mapping of Selected Major Functions to Current Locations

Location	Subfunction	Description
CDAS	Flight Operations	Capture of telemetry from spacecraft by ground station.
	Flight Operations	Processing captured telemetry to a format translatable by SOCC Software
	Flight Operations	Transmit and Capture ranging signals from the satellite
	Flight Operations	Capture Instrument Data from the spacecraft and provide to Instrument Processing system
	Level 1b products	Process Instrument data to level 1b. This system will also include a product monitor to insure that data processing requirements are met. While this function occurs at CDAS, it is controlled from the SOCC.
	Distribution	Level 1b instrument data is transmitted to PDGDS and other users via commercial satellite, ground lines or GOES-R (transmittal of the GRB data to GOES-R goes through the satellite operations)
	Product Generation	Store Raw Data Records for 3 days and Level 0 data for 30 days.
	Flight Operations	Format commands for transmission to spacecraft
	Flight Operations	Transmit commands to spacecraft. Provide for command authentication and verification.
	Archive and access	Store housekeeping data. In general, all spacecraft telemetry is kept for the life of the spacecraft. Removable storage may be used after a certain period of time.
SOCC	Flight Operations	Display telemetry data in a form that can be interpreted by controllers and engineers. This is the primary mode of monitoring the state of health of the spacecraft. Generally a table-like display as well as the capability to plot data is provided.
	Flight Operations	Format and transmit a single command to the CDAS for generation and transmission to the spacecraft.

Location	Subfunction	Description
	Flight Operations	Using a scripting language which includes logical and numerical constructions, format and transmit commands to CDAS for generation and transmission to the spacecraft.
	Multiple subfunctions	Monitor spacecraft for anomalous events. Determine when commands are needed and format and transmit commands according to a set of automated rules by calling a command script from the script library. This system will be used for routine operations and for well-understood workarounds and anomalies. Elements of this system may also reside in CDAS to improve response time for commanding.
	Flight Operations	Form bit-level commands from command mnemonics. This step is automatically called when commanding from the SOCC using Single, Scripted or Automated commanding.
	Flight Operations	Control all telemetry and data capture, commanding, instrument data capture and ranging functions remotely from the SOCC; remote operation of CDAS
	Multiple subfunctions (product processing & distribution)	Control processing of instrument data to level 1b from the SOCC. This system also interfaces with the product monitor and receives the results of its analyses; Remote operation of Instrument Processing
	Mission Management	Prepare command schedules based on User Requests, Maneuver Plans and Orbital events. Once the schedules are complete, apply rules to generate command loads. Using the Command Interpreter and the scripting function as needed, generate an integrated command load.
	Mission Management (Optimize System Design)	• Perform reliability analyses • Perform failure analyses (assess failure modes and consequences; develop contingency plans and mitigation approaches) • Assess automation approaches
	Instrument Operations	Determine the spacecraft orbit using data from ranging functions. Provide pointing files to CDAS and predictions for eclipse and other on-orbit events to Mission Planning and Users as needed.

Location	Subfunction	Description
	Mission management	Plan maneuvers based on orbit determination (OD). Provide inputs to Mission Planning to schedule appropriate commands to execute the maneuver.
	Instrument Management	Using OD products, provide instrument FOV and safety constraints to mission planning for inclusion in the command load
	Instrument Management	Receive ranging data from the spacecraft and process for use in OD
	Flight Operations	Monitor spacecraft and generate commanding scripts and/or single commands to insure that the satellite is functioning correctly. Generate operations reports describing the overall performance of the spacecraft.
	Flight Operations	Monitor S/C telemetry for trends. Include out-of-limit alarms and perform standard statistical test to determine anomalous behavior (even if the parameter is within limits). Use these data to detect specific faults. Also, perform real time trending and fault detection.
	Instrument Operations	Monitor Instrument and insure minimal degradation and maximum functionality for the life of the instrument. Generate operations reports describing the overall performance of the instrument
	Maintenance	Maintain ground segment hardware and software so that they provide effective command, control, data capture (instrument and spacecraft), data and command transmission and orbit determination functions for the life of the spacecraft. Track statistics on GS operations, performance, reliability and availability.
	Replenishment Planning	Insure that the system can be upgraded and replenished every 7 years at a minimum.